What's the Hold Up?
Are Existing Office Buildings Ready for Daylight Retrofits?

Lisa Heschong, TRC Energy Services

ABSTRACT

A recent study quantified enormous savings potential for daylight harvesting retrofits in existing office buildings. In California, over 31% of the 1 billion sf of existing office space could include cost effective photocontrols retrofits, resulting in statewide whole building savings of 459 GWH, and 184 MW of demand reduction. These numbers could be increased another 10% with the inclusion of simple interior improvements, such as daylight optimized blinds and furniture systems. A daylight harvesting program element could achieve net savings of 4-5% of all existing office building energy use in California! The potential in other states and cities is of similar magnitude, with New York City alone representing 10% of all US office buildings. Such a program would use simple, time-tested, commercially available retrofit measures with persistent savings and demand reduction.

Unfortunately, we do not know of any commercial retrofit program that is aggressively implementing daylighting retrofits—yet. *What is the hold up?*

This paper will detail the urban myths, misconceptions, market barriers, complexities, evaluation and regulatory barriers that are holding up realization of these technically achievable savings; and suggest solutions.

Daylighting retrofits are a classic integrated-design case study, where there are so many cooks in the kitchen, that one of them is sure to add too much salt! Furthermore, program managers and evaluators have shied away from the uncertainties created by natural variations in climate and occupant behavior which make savings less predictable at the individual project level, even when they are robust and predictable on aggregate.

Introduction: A Vast Untapped Resource

Energy savings from daylighting is getting a great deal of lip service across the United States, and figures strongly in recommendations for new construction especially for Zero Net Energy initiatives [NBI 2012]. However, there is an existing resource that is large, easily accessible, and virtually untapped: retrofitting existing buildings with photo-controls, especially existing office buildings. This paper will make the case that one measure—the retrofit of photo-controls into office spaces that are already daylit—could quickly reduce overall lighting energy use by these existing office buildings by 15%-20%. Similarly, careful studies have shown that a 4%-5% reduction in peak electric demand per building is also possible. The key question is, why is market adoption so slow?

The most recent CBECs study in 2003 reported 12.2 billion square feet of office buildings in the United States [EIA 2003]. New York City, with its high density commercial districts and towering high rises, represents 10% of the national building office building stock [Hinge 2012], and other major northern cities such as Chicago constitute other concentrations of high rise office buildings. However, per CBECs, over 50% of US office square footage is found in the Southern and Western regions of the country, regions with typically sunny climates.

Furthermore, over half of US office buildings are considered 'small' at less than 50,000 sf, and also most likely low rise. All of these types of offices can be served with daylighting retrofits.

The recent report "Let there be Daylight" makes a comprehensive case for retrofitting daylighting controls into New York city office buildings [Hinge 2012], estimating the magnitude of the potential impact, and noting importantly that 'decision making for these buildings is concentrated among a relatively small number of owners, managers and tenants." This same report also notes that 44% of the NYC office stock "was constructed prior to 1950, a period in which buildings were typically reliant on daylight and natural ventilation and there included numerous features to enable this…" Per CBECs [EIA 2003], over half (54%) of all office buildings were built before 1980; the average American office building will last for 65 years, and up to a third will last over 90 years. This constitutes a vast national building stock which could benefit from daylighting upgrades.

In 2006, the average office building was spending $2.42/sf in energy costs (2010 dollars) per the US Building Energy Data Book [DOE 2012]. Of energy, about 30% went to lighting, although the net cost of lighting, which varies considerably depending on local electric rates, is not broken out. Perhaps an even bigger motivation for daylighting retrofits than energy cost, especially for some utilities, is constrained transmission capacity in some areas, such as Manhattan or other cities, where peak load reductions are critical.

Office Building Windows

We all know that offices tend to have ample window area, mostly because occupants like to look out of them. Nice windows, and the corresponding views out, also are known to improve the real estate value of an office building. A study done in 2005 which attempted to put a value on windows and views found that 73% of commercial office building owners surveyed stated that they consider view when determining the rental value of their real estate offerings, (Kim 2005) and that for some vintages of office buildings, that the rent per square foot for high rise buildings doubled in cost over low rise options.

When looking to retrofit existing office buildings, often the building envelope, and particularly the windows, are considered the big targets for reducing energy consumption. It is important that the daylighting value of windows be preserved, or even better, enhanced during any retrofit. Most importantly, the visible light transmission of windows should never be reduced, without first looking for all possible ways to maximize utilization of the available daylight resource.

There are now window film treatments on the market that can improve the thermal profile of single glazed, and even double glazed windows, with little, if any, reduction in visible light transmittance. A recent emerging technology field monitoring study for PG&E suggests that while these films are good at reducing the heat loss through commercial windows, they generally have minimal, and sometimes even a negative impact, on cooling loads [Saxena 2014b]. The greatest opportunity for reducing the cooling load impacts of direct sunlight on office windows is to transform that sunlight into useful ambient light inside, displacing the need for more electric lighting and its associated internal heat gains. A study for the US Department of Defense, [Padiyath 2013], found that a 3M window film product which redirects sunlight upwards and deeper into the space can result in a net positive whole building energy balance across the continental United States (0.2 to 2.1 kWh/sf per yr), whether applied to windows facing east, south or west.

Thus, preserving the real estate value of windows for existing building retrofits, while transforming them into net energy advantages via the addition of photo-controls, should be a win-win effort in retrofitting existing office buildings.

Existing Office Daylight Potential Study for California

In order to put a finer point on these types of calculations of the daylighting resource available in existing office buildings, TRC (then, as the Heschong Mahone Group) completed a Public Interest Energy Research (PIER) funded study to assess the daylighting potential of the existing office building stock in California [Saxena 2011]. In order to do this, we re-analyzed over 600 office buildings across the state which had detailed on-site survey data as part of the 2004 CEUS [Itron 2006] survey. Additional information about the 600 buildings related to urban obstructions, trees, and observable window tint was added via examination of site photographs. We created detailed hourly simulations that mapped to over 6000 different façade and office space type conditions, which included typical partition and furniture layouts. This study used the most advanced method of estimating daylighting from these models available at the time, based on the Dynamic Radiance three-phase method, which included logical operation of blinds, according to hourly weather files and sun penetration.

Results of annual daylight available for each space was then summarized into a spatial Daylight Autonomy value, (Heschong 2011, IES 2013), along with potential lighting energy savings, and interactive effects with typical HVAC operation to develop whole building energy and peak demand impacts. This information for each building was then multiplied by the original CEUS sampling weights to expand the results up to the statewide population[1]. We also reported more detailed results by California climate zone and utility territory.

The study found that 31% of all existing office square footage had cost effective daylight savings available. The majority of the lighting energy savings, 76%, was immediately adjacent to windows, typically within eight to ten feet of the window, i.e., about one window head height in (considered the primary daylit zone). The corollary is that there is an additional 24% of lighting energy savings to be had deeper into the space in the secondary and tertiary daylit zones. Specifically, for the simple addition of photo-controls to existing conditions, the study found the following average savings for California, first for per square foot in the primary daylit zone:

At primary daylit zone level, i.e. within 1x window head ht.

- Average energy savings: **2.26 kWh/sf-yr**
- Average peak demand reduction: **0.85 W/sf**

and then all available lighting savings averaged across the total square footage of the building:

At a building level, average for all office buildings

- Average lighting energy savings: **0.62 kWh/sf-yr**
- Average lighting peak demand reduction: **0.23 W/sf**

[1] Actually, the 'statewide' values are only for the four largest utilities, representing 77% of the load in California. True statewide values may be 20+ percent higher than the numbers provided in this paper, depending on the demographic characteristics of the other California utilities..

These savings were then run through eQuest models for each building to access the interaction of lighting, heating, cooling and ventilation loads, in order to estimate the net whole building energy impacts. Even though all buildings saw an annual increase in heating loads, the next reduction in cooling loads actually increased the total annual savings an additional 13%:

At a building level, average for all office buildings

- Average net lighting and HVAC energy savings: **0.70 kWh/sf-yr**
- Average whole building peak demand reduction: **0.29 W/sf**

The lighting energy reduction translated into a 15% reduction in total building lighting energy use, and the net energy impacts translated into a 4.4% reduction in whole building energy use. And this is for an existing daylighting resource, with no enhancements—merely the implementation of photo-controls into pre-existing daylit spaces.

These resulting statewide energy savings potential are fairly dramatic: 459 GWh and 184 MW demand reduction; 0.2% and 0.3% of statewide usage respectively[2]. Keep in mind that this reduction is via the addition of just one technology, photo-controls, to just one building sector, existing office buildings.

The study went further to look at the additional savings that could be procured with very simple, low-tech, enhancements to the daylighting system, such as a change in room paint color, reduction in furniture system partition heights, or the addition of light shelves on sunlit windows. These enhancements could variously add 10% to 15% to 20% to the savings available. More sophisticated systems, such as sunlight-redirecting films and louvers, are also available (with increasing cost) that could potentially increase these savings by yet another 10%-20% [Perry 2012, Padiyath 2013]. Thus, the initial 4.4% reduction in whole building energy use by simply adding photo-controls could be pushed to over 5% or 6% with other daylighting enhancements.

Cost Effectiveness

In addition to demonstrating large potential energy savings, photo-controls have also been shown to be highly cost effective. Recent innovations, such as wireless controls, have reduced the cost of installation, and the labor for commissioning (Cx) the controls. While dimming remains at about a 50% additional cost premium over simple switching systems, both simple on-off photo-controls and dimming systems have been shown to be cost effective in office retrofits.

The Final Report for Daylighting Controls for the 2013 Title 24 development initiative [CASE 2013] undertook a comprehensive study of current photo-control costs for retrofit situations in California in 2013. The average installed and commissioned cost for a photo-control system to operate four lighting fixtures in a primary sidelit daylit zone was found to be about $560 (less for new construction). Assuming average energy costs of $0.12/kWh and 15 year life for the measure, the installed load threshold for the controls to have a positive net present value was 210 watts, or about seven 32 watt fluorescent tubes (and 120 watts in new construction, or about four tubes). Thus, merely three to four fixtures in a daylit zone justified the addition of photo-controls.

The incremental cost for also adding controls to the secondary daylit zone was a 52% increase, or $291. The net effect is that only 15% annual daylight savings were necessary to

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[2] Based on 265,000 GWh and 52,863 MW, per CPUC website http://www.cpuc.ca.gov/cfaqs/ accessed 3/6/14

cost-justify also adding photo-controls to the secondary daylit zone. Based on this analysis, and after adding in a safety factor, photo-controls were recommended to become a mandatory retrofit for all daylit spaces 300 sf or larger. This requirement, now adopted as Title 24 Section 149(b)2I, will begin to take effect for retrofits in California as of July of 2014.

Looking to the Future with LEDs

LED lighting systems are rapidly transforming the commercial lighting market, and may also take over retrofit options even faster than expected. In addition to high efficacy and long life, LED luminaires hold the promise of integrated multi-modal controls, with photo sensors and dimming capability in each luminaire providing highly granular control. It is true that the improved efficacy of an LED troffer will reduce the installed lighting power density and thus reduce the value of the net energy savings available from daylighting controls. However, the incremental cost for photo sensors and dimming capability will also be dramatically reduced, preserving the cost effectiveness equation. It is important to remember that in the primary daylit zone, photo-controls can always reduce lighting energy use by 50% to 80% during the day regardless of the efficacy of the system. Thus, integrating a daylighting retrofit initiative with replacement LED systems could provide even greater benefits to both building owner and utility.

What Is the Hold Up?

Although the aggregate potential savings are substantial; although photo-controls have been proven to be both cost effective [CASE 2013] and highly persistent [HMG 2005]; although the technology is decades old and well tested and understood; although installation of photo-controls can be done quickly, and involves little disruption of existing building operations; although inexpensive improvements like a change in paint color can dramatically improve savings—we are not aware of any utility efficiency programs that are aggressively pursuing photo-control combined with daylight optimization retrofits for existing commercial buildings. *Why not? What's the hold up?*

Many of the challenges for daylighting system success seem to be related to one of the basic joys of daylight: its inherent variability. The market barriers themselves are varied and complex [Rose 2014], but far from insurmountable. Rather, concerted effort could likely overcome all these issues, once there is acknowledgement of its need and value.

Admittedly, some technical challenges for photo-control installations do remain; but after thirty years of experience with automated daylighting control systems, these generally should be considered desirable refinements, not show stoppers. Most of the remaining technical challenges are being addressed by continuing national efforts or simple work-arounds, as described below. None of them should be considered to be preventing the roll out of a daylighting retrofit program based on simple, state-of-the shelf technology.

Below, we will briefly consider some of the remaining technical challenges and current efforts underway to address them. However, the longer term challenge may be to find a way to address a number of underlying, and often unconscious, cultural attitudes that seem to consistently undermine the success of daylighting systems, also delineated further below. Changing culture attitudes is difficult, especially intentionally, because it requires a broad consensus of market actors to create a consistent strategic campaign that gradually shifts the behavioral norms and expectations. However, many public health campaigns have achieved success in the past, and provide hope that a daylighting marketing campaign could have similar long term impacts. Applying the 'market transformation' experience of the energy efficiency industry, with coordinated multi-year marketing campaigns, may ultimately prove most useful to achieve the necessary cultural shifts.

Technical Challenges and Current Solutions

Occupant visual comfort preferences. The control of electric light in relation to the dynamic availability of daylight is one of the basic challenges of good daylight harvesting controls. It is clear that occupants' perception of the brightness and acceptability of visual environment is only loosely related to the horizontal lumens that are traditionally used to set performance targets for electric lighting systems. The quality, interest, brightness and clarity of a view, along with patterns of brightness and contrast on interior vertical surfaces, are also likely important factors, but they have not yet been quantified. While research on visual comfort under daylit conditions is sorely needed, no obvious funding sources are in sight. Thus, currently, success is more commonly a result of skilled design experience, intuition or happenstance than a result of bio-engineering formulas or predictive equations. The simplest approach is to avoid over optimization, so that there is always more light than minimally necessary. Easy to follow rules of thumb could also help increase the chances of success [Van den Wymenlenberg 2012].

Training installers and technicians. It is understood that system design and commissioning are often the weak link in photo-control installations. Many studies have documented poorly designed or executed systems that do not perform to expectations [Hackel 2013]. In order to address this need, a group of California utilities created the California Advanced Lighting Controls Training Program, and, with support of DOE and NEMA, are working to spread the training and support programs nationally [NALCTP 2014]

Predicting savings. Daylighting savings are by their very nature highly variable, fundamentally as unpredictable as the local weather, but with the added dimension of the unpredictability of human behavior controlling blinds and lights in response. This is an engineering challenge that has been solved many times in the past, for example, for HVAC systems and utility grid demand. Fundamentally, daylighting savings should be looked at on aggregate, across many installations that smooth out the local variability, and thus provide a statistically reliable prediction of average savings. Doing this well requires the compilation of more data than we currently have; but data is rapidly becoming ever cheaper to collect and analyze, and this challenge promises to be overcome soon. In the meantime, the California utilities are sponsoring the development of a new calculation tool for multi-modal lighting controls that will include hourly calculations of daylight performance based on local weather and other key variables. Called the Advanced Lighting Controls System, this calculator is expected to be available for testing by the end of 2014 [private communication, Chris Corcoran, PG&E, March 2014]

The dollar value of daylighting savings. Back when electric lighting was wildly inefficient and largely uncontrolled, the dollar value of the energy savings from daylighting controls was substantial. As we move from lighting installations of 3W/sf to 1W/sf and less, and as occupancy sensors and other controls become commonplace, the incremental savings from daylighting also becomes corresponding less. There are many folks in the lighting industry who think that the cost effectiveness of daylighting controls will be extinguished with the advent of commodity LED ambient lighting systems. In this view, once again, just like in the 1950's, the ambient lighting will be so inexpensive to operate that it won't be worth anyone's while to turn it off. However, this argument ignores the observation that controls integration with LEDs is also getting dramatically cheaper and more capable. It would seem more likely that LEDs will be an enabling technology that will make it ever easier to use electric light only where and when we need actually it. This would be a vision more compatible with a national goal for Zero Net Energy buildings, where electricity is used in our buildings as parsimoniously as possible.

Urban Myths

In addition to legitimate technical challenges, such as discussed above, there are also many common misconceptions about daylighting systems, a.k.a. 'urban myths' that inhibit wider adoption.

Daylighting only works for north or south facing windows. A study of the high performing daylighting system at the Genzyme headquarters building in Cambridge, MA found that on average over the course of a year, daylight savings were substantial, and the same for all four orientations of the building. [Howlett 2011] With thoughtful design that solves the problem of glare from low angle gun, east and west facades can produce as much daylighting savings as north or south facades. Toplighting solutions, such as skylights and clerestories, can be completely independent of orientation.

Light shelves are a pre-requisite for well daylit spaces. During a recent search for exemplary daylit sites in New York State, the TRC study team found that many architectural and lighting designers conflated 'a daylit space' with the presence of light shelves. It is true that it is a good idea to provide some form of separate control for the upper portion of windows to ensure a minimum level of daylight penetration, even when window blinds need to be closed to block direct sunlight. However, there are many other less expensive, less intrusive options, such as inverted blinds, louvers, or window films that can also redirect sunlight upward and inward.

Dimming ballasts are a pre-requisite for daylight harvesting. Similarly, there is a wide spread belief that daylighting controls are synonymous with dimming controls, and therefore require expensive dimming ballasts. The Greenlight New York study strongly recommends that only dimming ballasts be considered for office daylight installations to order to avoid occupant distraction and annoyance [Hinge 2012]. This is certainly a valid concern for spaces with highly variable daylight due to intermittent clouds, shadows, or reflections. However, the current $20+ premium for each ballast replacement will definitely make daylight controls a high cost hurdle.

However, in the primary daylight zone, where 76% of all daylight savings reside, it is important to recognize that there are typically only two switching events per day: early morning and late afternoon. This is true even under cloudy conditions. The solution, then, can be to control only those areas with very high Daylight Autonomy, on the order of 80%, with a low-cost, bi-level switching system. If switching events are set to occur when they are below the perception of the occupants, i.e., once daylight levels are already substantially above illuminance design targets, then these systems can have high acceptance.

Window blinds will block most of the daylight. There is a widespread belief both in the energy community and among designers that window blinds are usually left closed, and block most the useful daylight. While it is true that window blinds are ubiquitous [Heschong 2011], and are important in providing occupants with options for privacy and control of glare caused by direct sunlight and reflections, it is not true that they block the majority of available daylight, or that this is a hopeless problem, outside the influence of designers. One of the best motivations for occupants to open their blinds is to obtain a pleasant view. Glen Hughes, project manager for the New York Times daylighting installation, reported his observation that the better the view, the more often the automated window shades were overridden to be open, in spite of sun penetration [private communication, Glen Hughes, August, 2007].

Daylight savings are not persistent. Conference papers and journal articles are full of reports of highly touted daylit buildings that did not produce the predicted savings, most often due to poorly operating or disabled controls. However, a landmark study on the actual field performance of photocontrols found that, once commissioned correctly, the controls continued to perform to expectations without further adjustments for years, and sometimes decades [HMG 2005]. Thus, there is strong evidence that once controls are installed and commissioned correctly, they continue to operate correctly with little, if any, attention required. Thus, the challenge for improving performance is at the front end with proper installation and commissioning, per the training discussion above, not the back end during operation and maintenance.

Cultural Challenges

Cultural expectations tend to operate below the level of conscious perception, and thus are often unexpected, and difficult to detect, and difficult to change. After over 100 years of experience with electric lighting, Americans have developed a set of deeply held expectations about their indoor lighting systems that often work against the adoption of daylighting controls:

"Lights on" means "I'm at work" and "I'm open for business". "Keeping the lights on" has become synonymous with "business is up and running." Office workers have been known to leave their office lights on to indicate their presence nearby, and retailers are typically loath to turn off ceiling lights for fear that customers will think they have closed for the day. It may seem trivial, but American culture clearly needs another highly visible indictor of purposeful activity. Large glowing neon signs (now LED?) declaring "Open" may do the trick for store-front retailers. Outdoor farmer's markets don't need 'open' signs, since activity is obvious from afar. Office workers who can be easily seen at open workstations don't need secondary visual indicators, but inside of private offices a small indicator light at the door might help do the trick, something like the 'on air' sign which lights up outside of TV studios.

"If the electric lights don't turn on, something must be broken": Decades ago, Americans developed the expectation that when you flip a switch, the lights will go on. If you turn on a switch and the lights don't come on, the common assumption is that the lights must be burned out or dysfunctional. When photo-controls prevent an overhead light from turning on, there should be some way to communicate that 'no lights on' is intentional, and the systems is indeed working correctly. It would be helpful if an indicator light or display somewhere acknowledged the action, and provided information about the current state of the system. A thermostat-type readout display of 'current illumination conditions', or 'energy savings in progress' might provide such a feedback message. Is there an 'app' for that?

Some of us remember grandparents who came of age in the early twentieth century who simply could not stand to have electric lights left on unnecessarily. But the majority of the American population by the 1960s came to associate the pervasive overhead electric lighting operating under low cost electricity to simply be part of the expected indoor landscape. It may take a generation of two to get the population fully comfortable with a more naturalistic indoor environment that does not include automatic 'lights on'. If this is the case, then focusing efforts to create daylit schools may be an effective pathway to change cultural expectation for the next generation.

Project Coordination

Current daylighting systems also do not fit in well with our cultural preference for simple, plug and play, out-of-the box, one-size-fits-all, branded products, with a singular IP (intellectual property) owner who has clear profit motives driven to optimize the marketing message and delivery channels. Instead, daylighting retrofit systems tend to swim in the realm of multiple disconnected market actors, victim to the difficulty of maintaining coordination across time, multiple professions and budget sources. For example, Table 1 below describes how a comprehensive office daylighting retrofit might involve quite a number of independent decision makers and budgetary sources:

Table 1. Potential actions and actors for optimized daylighting office retrofit

step	system	actions	actors	budgets
1	window	remove or add films, and/or exterior shading, to improve daylight availability, thermal comfort	architect or facility manager	owner's maintenance
2	ceiling	raise ceiling when possible, paint ductwork, address acoustic concerns	architect or facility manager	owner's maintenance
3	partitions	relocate to improve daylight penetration, add glass for transparency and view	architect or facility manager	tenant improvements
4	room surfaces	select higher brightness ceiling tiles, carpets, and/or wall paint	interior designer	no cost
5	window blinds	change and/or automate blinds or shades to optimize daylight availability, manage glare	interior designer	tenant improvements
6	furniture	select and layout furniture to take advantage of daylight and to improve daylight penetration	interior designer	tenant's capital budget
7	lighting system	select new fixtures to improve efficiency, and compatibility with daylight distribution and color	lighting designer or electrical engineer	tenant improvements
8	lighting controls	add photo controls, zoned to optimize daylight savings and minimize distraction	electrical engineer and/or contractor	tenant improvements
9	lighting controls	commission lighting controls, once all other decisions are implemented, and space occupied	electrical contractor and/or Cx agent	tenant improvements
10	furniture	add task lighting as supplement to ambient daylight, on as needed basis for occupants	tenant's purchasing department	tenant's operations
min/max	**1 to 7**	**2 to 10**	**1 to 6**	**1 to 4**

It is important to note that for many projects, <u>only two steps are essential</u>: step 8, add photo-controls, and step 9, commission lighting controls. However, all the other steps offer potential for decisions than can improve daylight availability and management, resulting in both greater energy savings and occupant satisfaction. Thus, as the table illustrates, a comprehensive retrofit project might involve coordination across seven systems, with six actors making ten decisions that are constrained by four different budgetary sources. Most decisions can be made a minimal additional cost, and some with no cost at all. None of this is particular difficult or technically challenging; but the flip side of the argument is that one bad decision by one of these players can undermine the efforts of all the others. Achieving sustained coordination across so many players and decisions and budgets implies that the end goal—an optimally daylit space—must remain front and center on everyone's priority list over the entire course of the project; a difficult condition to achieve.

"Daylight Decision Bundles"

One solution for this coordination challenge that has been successfully implemented by many industries, is the creation of 'bundles' of options that are grouped into a few discrete options for the buyer. Perhaps first implemented by the clothing industry with the idea of standard sizing for ready-to-wear, off-the-shelf men's clothing in the early twentieth century, the idea has since been picked up with a vengeance by the cable TV industry, the cellphone industry, and most recently the US national health care initiative. Package A, B, or C simplifies a multitude of decisions into three. Nobody gets a perfect fit, but everyone spends less time getting an approximate fit. The US Green Building Council transformed the focus of building industry by creating a similar system for owners to select silver, gold and platinum LEED packages for green buildings.

So, perhaps the question is, can the options for the ten or more steps illustrated in Table 1 be simplified into a few standard retrofit packages for office building owners? Imagine a utility program where office owners were asked to select among three options:

- **Fully Automated Package A**, dimming with automated shades, and a low-rise furniture system
- **Occupant Benefits Package B**, light redirecting film with task/ambient lighting
- **Basic Package C**, bare bones switching with a paint and carpet color upgrade

Successful packages, however, require extensive market experience to hone the preferences of many customers into a few, well-crafted options. Thus, in order to create successful packages, a program manager should already have substantial and varied market experience. Furthermore, the added value of the premium package should be clear and obvious to the customer. The challenge, then, is to get this level of market experience and widely known evidence to make a packaged marketing approach work.

Premium Packages

The premium package, in any market, has even more allure and value if it is associated with some high-status outcomes, and not based just on simple cost effectiveness. It may be that the energy efficiency world's obsession with cost effectiveness is actually creating market barriers to adoption, by stressing only monetary decisions, and undermining social and cultural motivations. Retrofits strictly motivated by cost-effectiveness will always push for the low cost solution. Retrofits motivated by market competition, on the other hand, will seek to make a building or space as attractive to new occupants as possible. Market competition is often a much more powerful force than cost-benefit analysis, and one of the few motivations in the real estate industry that pushes for integrated solutions, valued for the whole rather than the parts.

Utilities and states stand to gain substantial public benefits from energy savings and demand reduction, and the value of any incentives offered should be based on those benefits. Building owners and occupants, on the other hand, also stand to benefit from the many 'non-energy' aspects of a daylighting system. Thus, providing marketing materials that document and emphasize the non-energy benefits of daylighting systems is more likely to speed adoption than further honing the cost-effectiveness equation.

Thus, a better question to ask might be: "does Class A office space include daylighting?" Is a well-performing daylight system part of the expectations of gen-X high-tech, high-rent tenants? Do daylit spaces command higher rents and spend less time vacant?

Need for a Coordinated Programmatic Effort

In some ways, the cultural barriers to daylighting are extra challenging because of the sustained effort needed to shift cultural norms. In other ways, it is easy and achievable, with few, if any, technical challenges. It is not dissimilar to many public health programs, changing cultural priorities away from littering, away from drunk driving, away from smoking. Many small nudges and changes in default assumptions produce a slow but steady cultural change that adds up over time. Our presumption that a switch will always turn on the lights is a cultural expectation built up over decades of experience. It has a lot of inertia, but cultural expectations can be changed, with consistent and reinforcing information.

Given the magnitude of the energy savings potential, and the urgency to achieve energy use and demand reductions in existing buildings, initiating a comprehensive campaign to install photo-controls into, and further optimize the daylighting savings available from, existing office buildings across the country offers a huge opportunity. Many outstanding technical issues have already been addressed, and progress is being made on many others. The greater challenge may be addressing the cultural expectations about indoor environments, based on our national experience over the past century with electric lighting, that run counter to the performance of daylighting systems. Some cultural change may already be in the works, based on the new world of digital communications and the younger generations' expectations of operating in a less structured environment. But the successful daylighting systems could also benefit from a comprehensive and coordinated effort to market these systems as if the well-being of our world depended upon it.

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